Programme Specification

MASTER OF RESEARCH: ULTRA PRECISION ENGINEERING

<table>
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<tr>
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<th>Awarding body</th>
<th>University of Cambridge</th>
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<tr>
<td>2</td>
<td>Teaching institution</td>
<td>Department of Engineering</td>
</tr>
<tr>
<td>3</td>
<td>Accreditation details</td>
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</tr>
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<tr>
<td>6</td>
<td>JACS code(s)</td>
<td>H700; H710; H790</td>
</tr>
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<td>7</td>
<td>Relevant QAA benchmark statement(s)</td>
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<td>8</td>
<td>Qualifications framework level</td>
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<td>9</td>
<td>Date specification was produced</td>
<td>June 2015</td>
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Introduction

The University of Cambridge and Cranfield have jointly been awarded a Doctoral Training Centre (CDT) in Ultra Precision Engineering (UP) by the EPSRC. The CDT is held administratively at Cambridge but Cranfield is a supporting partner. Funding has been obtained for 6 intakes of students starting in October 2012. The CDT is a four-year programme, with a one-year taught Master’s course followed, assuming a suitable achievement level in the Master’s, by a three-year PhD programme.

It is intended that students are admitted to a Master’s course at Cambridge and then progress to the PhD programme, possibly transferring the institution of registration at this point. As a result, the programme aims not only to teach the fundamentals of Ultra Precision Engineering, but also to equip the participants with research skills suitable for academic and industrial research and development programmes, in particular equipping students with the skills and experience to enable them to have a head start in their PhD research programme.

It is possible for students to take this course as a stand alone course, without progressing to the PhD, though they are not able to do this with funding from the CDT. The MRes course is intended to be sustainable and continue beyond the 7 intakes of the EPSRC CDT funding.

Educational Aims of the programme

The programme is designed to produce engineering leaders with training in many advanced ultra precision technologies and processes including: laser micro processing; focused ion beam machining; reactive atom plasma processing; micro mechanical machining; nanofabrication; graphene engineering; printed electronics, and advanced metrology systems.

The programme aims to:

- Produce engineering leaders with a high level of understanding and skills in ultra precision, in particular the fundamentals of the field together with the necessary research expertise, technology, systems and applications knowledge.
- Develop strong business awareness in MRes graduates and foster an understanding of the foundations of management theory and the connections between technology, management and entrepreneurship.
• Encourage an appreciation of applications drivers for ultra precision systems technologies and the business, road-mapping and cost analysis tools used to determine the adoption of new technological solutions.
• Expose the students to a range of technology areas and provide an experience of a variety of different research and development cultures, via the use of mini-projects, from blue skies university lab to short term industry development projects.
• Enable students to study across discipline boundaries, with a resultant enhancement of interdisciplinary understanding.
• Equip the graduates of the programme with generic communications skills as well as research specific training to enable them to make a seamless transfer to doctoral research programmes at Cambridge, Cranfield, or another UK University.

Programme Outcomes

The programme is designed to develop the following broad themes:

• **Fundamentals** of ultra precision systems in the broad areas of machine design, metrology, optical testing, machine dynamics, displays, lasers, ion beams, micro manufacturing, surface engineering (F)
• **Concepts** of, and strategies for, ultra precision system design and implementation (C)
• **Research** experience via mini and group project placements in university research groups and industrial R&D facilities (R)
• **Aspects of business**, innovation and technology development (B)
• **Awareness** of best practices through an industrial visits programme

These will provide opportunities for students to develop and demonstrate knowledge and understanding, skills and other attributes as follows:

Knowledge and understanding

• Fundamental trends and concepts in ultra precision systems.
• Understand the underlying physical technology background to ultra precision systems in the areas of precision machining, materials, industrial photonics energy beam processing, and photonic devices.
• A broad knowledge of ultra precision systems in the areas of e.g. electronic and photonics, displays, sensors, and industrial processing.
• Familiarity with a range of specialist topics, e.g. optical metrology, nanofabrication, computer aided design, control, image processing, laser and ion beam processing, machine dynamics.
• Good laboratory and research practice based on industrial and university research programmes and the ability to report research outcomes in an appropriate way for the intended audience.
• Understanding business practice and tools in the areas of technology and innovation management, technology transfer, and exploitation, with particular emphasis on the ultra precision industry.

Intellectual skills

a. Be able to solve technical problems in the area of ultra precision systems, in terms of underpinning aspects, product development, and applications.
b. Be able to apply generic skills in modelling, simulating and experimentally evaluating ultra precision systems in order to design, optimise and improve them.
c. Be capable of critically evaluating technical problems and examining alternative approaches and technologies to solve them.
d. Be able to carry out surveys of existing technologies and research topics, and provide a detailed and critical overview of a technology or research area.
e. Be able to deal with complex research issues both systematically and creatively, make informed judgments in the absence of complete data and in unpredictable situations.
f. Be able to understand commercial exploitation routes for ultra precision based technologies and evaluate options for technology transfer and/or implementation.
g. Plan, execute and critically evaluate original and individual pieces of research work via mini projects.

Transferable skills

h. Prepare formal reports in a range of styles suitable for research dissemination (e.g. journal paper, conference paper, oral and poster presentations, literature review, extended project report).
i. Reason critically and demonstrate and exercise independence of mind and thought and communicate ideas.
j. Manage time and work to deadlines, work effectively both independently and in groups, and assess the relevance and importance of the ideas of others.
k. Ability to find information and learn effectively for the purpose of continuing professional development and in a wider context throughout their career. In particular carry out literature reviews and patent searches, using library and online tools.

Teaching, learning and assessment methods used to enable outcomes to be achieved and demonstrated

MRes teaching is carried out at both Cambridge and Cranfield using existing Master’s level courses where appropriate and the development of new laboratory classes and courses specifically designed for the CDT-UP. It is anticipated that some of the mini-projects will be carried out in industrial labs. Lectures, small group teaching, student-led and tutor-led seminars, field visits, guest speaker presentations and case studies, short block courses, and individual research projects leading to dissertations, will combine to provide a rich and varied learning experience for the CDT-UP graduates.

Assessment

Assessment will be by examination, coursework (individual and group), class participation, presentations (individual and group) and individual project dissertation. There will be close co-operation between Cambridge and Cranfield to validate the assessment of the teaching modules and research projects. The delivery of the MRes taught programme will be overseen by an External Examiner.

Programme structures and requirements, special features, modules, credits and awards

The MRes programme is only offered as a full-time course. The taught course will last for 11 months (October – August inclusive) and leads to the award of an MRes degree.

Students must complete at least five mandatory modules and eight laboratory classes, in addition to a group research project and one long research project (60 credits each) based at either Cambridge, Cranfield, or in a collaborating company.
Special innovative features of the programme are as follows:

- All of the staff involved in the presentation of the programme have a strong background in ultra precision systems research and associated subjects, and so the course is firmly rooted in up-to-date research practice.
- Teaching is provided by senior figures from both Cambridge University and Cranfield University, and is supplemented by a range of guest speakers including Prof Richard Leach from the NPL, and Prof Robert Munning Schmitt from Delft. In this way the course is able to reflect current best practice in the area of ultra precision systems development.
- The ability, and indeed requirement, to take courses and laboratory classes across departments in Cambridge and with Cranfield will broaden the student experience and widen their perspective of the field.
- Students will be required to undertake a fixed collection of modules that will deliver to them an educational framework which is relevant to the study of ultra precision systems and which will give them the expertise necessary to continue to study at PhD level.
- There is good collaboration with other Master’s programmes both at Cambridge and Cranfield.
- Weekly sessions on transferable skills, particularly those suitable for a research career, will allow students to obtain skills which will help them to carry out background study, plan their time and present their results.
- A strong emphasis on learning via projects will enable students to gain a deep understanding of particular topics as well as developing background research, analysis, simulation and technical problem solving skills. The requirement to carry out the mini-projects in different locations, either at the two universities or in industry, will further broaden students’ outlook.
- Individual long projects will be a main output of the MRes and lead to a thesis, a poster paper and oral presentation at the yearly research event held by the EPSRC centre. Projects will be sponsored by companies and will align to the EPSRC centres’ Research Portfolio. Prof O’Neill is the CDT-UP Director; he is also the Centre’s Research Portfolio manager, ensuring alignment of these demands.
- Group projects will form an important aspect of the MRes course. These Group Projects will be defined such that they support of the creation of the EPSRC Centres Research Platforms. Industry inter-action will be assured through the companies engaged into the realisation of the Platforms. Holding the focus of Group Project topics onto the Research Platforms will ensure a number of the MRes-trained students can be immediately become effective into the research development of the Platforms during their years 2-4.
- Individual and Group projects will form 45% of the MRes course. The projects will be defined and introduced early during the first term. In so doing, students can consider and develop concepts towards these projects from the onset of their post-graduate experience. In the case of the Group Projects the longer duration will ensure team-building and team development phases are sufficiently advanced to ensure important deliverables are attained.

Course Structure and programme content:

The list below is intended to be indicative of modules offered, though individual availability will vary in each year, depending on lecturer availability and advancements in the field. The Degree Committee will announce all modules prior to the start of the course.
Modules and Laboratory Classes (all students)

<table>
<thead>
<tr>
<th>Location</th>
<th>Module Title</th>
<th>Activity</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CRAN</td>
<td>Precision Engineering</td>
<td>F</td>
<td>15</td>
</tr>
<tr>
<td>CRAN</td>
<td>Metrology &amp; Optical Testing</td>
<td>F</td>
<td>15</td>
</tr>
<tr>
<td>CAM</td>
<td>Energy Beam Micro Processing</td>
<td>F</td>
<td>15</td>
</tr>
<tr>
<td>CAM</td>
<td>Display Technologies, MEMS Design, Nanotechnology or Photonic Systems</td>
<td>C</td>
<td>15</td>
</tr>
<tr>
<td>CAM</td>
<td>Technology and Innovation Management</td>
<td>B</td>
<td>15</td>
</tr>
<tr>
<td>CAM</td>
<td>Laboratory Class</td>
<td></td>
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<tr>
<td>CRAN</td>
<td>Reactive Atom Processing</td>
<td>C</td>
<td>5</td>
</tr>
<tr>
<td>CRAN</td>
<td>Optical Test &amp; Measurement</td>
<td>F</td>
<td>5</td>
</tr>
<tr>
<td>CAM</td>
<td>Ultra Fast Laser Processing &amp; Metrology</td>
<td>F</td>
<td>5</td>
</tr>
<tr>
<td>CAM</td>
<td>Focused Ion Beam Machining</td>
<td>F</td>
<td>5</td>
</tr>
<tr>
<td>CAM</td>
<td>Roll to Roll Printing &amp; CNT fabrication</td>
<td>C</td>
<td>5</td>
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<tr>
<td>CRAN</td>
<td>Machine Modal Analysis</td>
<td>F</td>
<td>5</td>
</tr>
<tr>
<td>CRAN</td>
<td>Single Point Diamond Machining</td>
<td>C</td>
<td>5</td>
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</table>

Dissertation (All students: December – August)  
e, f, g, i, j, k

Group projects and long projects (based in two of CAM, CRAN or industry)  
(60 credits each)

Support for students and their learning

- One week induction programme for orientation, team building and foundation teaching
- Student handbooks and electronic on-line teaching support and access to course materials
- Small group teaching
- Staff student liaison committee for feedback and course management
- Personal access to Course Director and staff concerned with delivering this course
- Opportunities for overseas study as part of dissertation
- Regular informal discussion seminars and industrial visits
- Research methodology course and other support seminars (careers, progression to PhD, safety etc)
- Research Project Conference with participation from both students on this course and with students who have graduated to the research part of the CDT programme (with invited industrial guests and other experts)

Advisory Structure

Management arrangements will draw on the substantial experience of the management of research projects and PhD students between the groups at Cambridge and Cranfield acquired through joint EPSRC grants such as the IMRCs and IKCs. A CDT-UP subject group, chaired by the Director, composed of Cambridge and Cranfield academics, and industrial members will meet once per term to track the performance of the centre activities, forge links with other universities and EPSRC CDTs, establish greater levels of industrial engagement in consultation with the EPSRC Centre in Ultra Precision’s National Coordinator, and provide feedback to the main EPSRC Centre in Ultra Precision’s Executive and Steering Committees.

The CDT-UP is highly complementary with other CDTs in Cambridge, namely the CDT in Photonics (shared with UCL) and CDT in Nano Science and Technology. Applicants have wide ranging links with these centres, such as facilities exchange and short project options. We plan to further extend these links by allowing other CDT students access to the facilities within the EPSRC Centre in Ultra Precision, and attendance at the annual PhD student-led conference and research seminars.
Criteria for admission

A robust interview programme for applicants will involve panel interviews, tours of facilities, and opportunities to meet with existing students. This approach will be effective in choosing candidates who will thrive in the research environment offered by a CDT. Students on the programme will have well-developed technical skills in engineering, science, and preferably some professional work experience. The course is broadly based and inter-disciplinary and welcomes applicants with backgrounds across the physical sciences, including chemistry, physics, materials science and engineering, having obtained a first or upper second class honours degree (or equivalent). Owing to the CDT's funding arrangements, only Home and EU applicants can be accepted.

The management of quality

Management of the quality of the programme is the responsibility of the Course Director and the CDT-UP subject group. Students are encouraged to give immediate verbal feedback to staff teaching on the programme and to the Course Director. Feedback channels are also formally implemented through a Staff-Student Liaison Committee, attended regularly by the student representatives. Students are asked to complete quantitative and qualitative feedback questionnaires, which address questions on the following issues:

- Quality of teaching
- Quality of supervisions
- Quality of visual aids and teaching environments
- Relevance of subject matter
- Workload
- Admissions process
- Facilities (study space, IT, library resources etc)
- Quality of administrative support

Results of questionnaires will be distributed to the relevant teaching staff. The academic content of the programme will be continually reviewed by the Course Director, and strategically reviewed at the end of each year of operation by the CDT-UP subject group.

An External Examiner will monitor the quality of the programme during the year, attend the annual Examiner’s meeting, and will submit a report to the Vice Chancellor at the University of Cambridge.

Having passed the MRes course assessments and been allowed to move forward to years 2-4, the CDT-UP PhD student will have access to three supervisors, two academics in the form of a principal supervisor and an advisor, and one industrial supervisor that will take responsibility for management of the student within a sponsoring company. The principal supervisor will be the main point of contact for the student for all matters relating to the research. In addition to regular PhD supervisions throughout the year, each student will be expected to submit an annual progress report which will be reviewed by the principal supervisor and advisor. In practice the principal supervisor will be in close contact with any industrial supervisors that may be engaged through collaborative activities.
Summary of Assessment Regulations

In order to obtain a degree students registered for the MRes in Ultra Precision will be required to obtain:

- An average of 60% or greater over the 5 required modules
- An average of 60% or greater over the 7 required laboratory exercises
- A pass for the group and long projects (aggregate 60% or greater)

Both the taught components and the dissertation must be passed individually to gain an overall pass on the course. Cases of marginal failure (i.e. 55%-59%) in one of the three components of the degree may be redeemed by high performances in the other two elements (at least an average of 70%).

The classification of the MRes degree will be awarded as either pass or Distinction. Students who achieve an exceptional performance (i.e. greater than 75% average in all three components) may be awarded a Distinction.

Graduate Employability and career destinations

The Careers Service maintains links with relevant employers and takes into account employer needs and opinions in the services which it provides for students. The Careers Service also allocates a Careers Adviser to each College, Faculty and Department to act as a point of contact.

Please note: This specification provides a concise summary of the main features of the programme and the learning outcomes that a typical student might reasonably be expected to achieve and demonstrate if he / she takes full advantage of the learning opportunities that are provided.

It follows from the nature of the rapidly evolving subject matter that some detailed course elements may change from year to year to reflect emerging themes in Ultra Precision Engineering.

Every effort has been made to ensure the accuracy of the information in this programme specification. At the time of publication, the programme specification has been approved by the relevant Faculty Board (or equivalent). Programme specifications are reviewed annually, however, during the course of the academical year, any approved changes to the programme will be communicated to enrolled students through email notification or publication in the Reporter. The relevant faculty or department will endeavour to update the programme specification accordingly, and prior to the start of the next academical year.

Further information about specifications and an archive of programme specifications for all awards of the University is available online at: www.admin.cam.ac.uk/univ/camdata/archive.html